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ABSTRACT

This update reports on the highlights of a year-long evaluation of the influence of "Science for All Americans" and "Benchmarks for Science Literacy", two landmark publications of the American Association for the Advancement of Science (AAAS). Data for the evaluation were collected through expert interviews, reviews of state science curriculum frameworks and textbooks, telephone and mail surveys, and case studies of reform activities in six states. The areas summarized from the larger report include national impact, state impact, individual impact, establishing a strong foundation for change, tools for change, putting learning goals to work, shaping the national agenda, guiding reform in the United States, and long-term visions. The projects described and used as examples within this report are from the states of Georgia, Rhode Island, Indiana, Pennsylvania, Texas, California, and Massachusetts. (DDR)

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Update 1997

Project 2061

Science Literacy for a Changing Future

ED 406 228

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Since 1985, Project 2061 of the American Association for the Advancement of Science has pursued the goal of science literacy for all. In its two major reports, *Science for All Americans* (1989) and *Benchmarks for Science Literacy* (1993), Project 2061 describes the knowledge and skills adults will need in science, mathematics, and technology and recommends learning goals for students as they make progress toward science literacy.

Results from the Third International Mathematics and Science Study (TIMSS) indicate that science literacy is far from a reality for most U.S. students. According to the TIMSS data, the nation's curricula, textbooks, and teaching lack focus; emphasize quantity over quality; and are all "a mile wide and an inch deep." Project 2061's approach to reform begins with the curriculum by defining its content and identifying the most important concepts so that students can learn those core ideas well. Project 2061 calls for similar changes in textbooks and teaching practices. And, to support all of these reforms, Project 2061 proposes a number of long-term changes at every level of the education system.

Many of Project 2061's recommendations are echoed in the National Research Council's new *National Science Education Standards* and in the curriculum frameworks developed by states and school districts. Through its products, workshops, and presentations, Project 2061 offers help to educators attempting to design curriculum and instruction around a coherent set of explicit learning goals, such as those in *Benchmarks*.

Nevertheless, reforming the entire K-12 education system to ensure science literacy for all Americans is a long-term endeavor, one that will extend well into the 21st century. It requires the coordination of national, state, and local reform efforts and active support from all parties concerned with education—teachers, school administrators, parents, university faculty, policy makers, employers, and the general public. Such a proposition is a daunting but achievable goal. This booklet will describe some of the ways in which Project 2061's efforts—along with those of other reform initiatives—have already had a profound impact on many key areas of the education system.

PROJECT 2061
Having an Impact

At the request of The Pew Charitable Trusts, one of Project 2061's principal funders, SRI International recently concluded a year-long evaluation of the influence of *Science for All Americans* and *Benchmarks for Science Literacy*. Data for the evaluation were collected through expert interviews, reviews of state science curriculum frameworks and textbooks, telephone and mail surveys, and case studies of reform activities in six states. Here are some of the highlights of the SRI study:

"...a coherent, comprehensive, and compelling vision of science literacy.

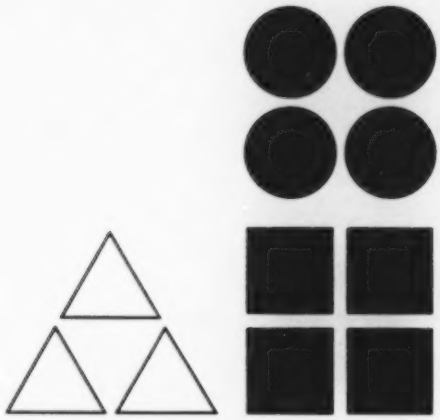
SRI INTERNATIONAL, 1996

National Impact

- According to the SRI report, *Science for All Americans* and *Benchmarks for Science Literacy* reflect the "best thinking in science education reform..." and Project 2061 has "provided a banner around which science education reformers could rally...." By widely promoting the documents to scientists and educators, SRI says, Project 2061 has "changed the national climate for science education reform...."
- Project 2061 has brought into the mainstream of education discourse some core ideas about science education reform: that science is a subject to be learned by all students; that science programs must be coherent, not just a collection of random facts and activities; and that the natural and social sciences, mathematics, and technology are interrelated.
- Project 2061 has been a major influence on the development of national science education standards and on reform initiatives sponsored by the National Science Foundation, the U.S. Department of Education, and a number of other national education and science organizations.
- Project 2061's influence on science textbooks can be seen most readily in the books' introductory passages and in the annotated teacher's guides. To a large extent, however, it appears that reform ideas such as those promoted by Project 2061's publications and the science standards have not yet been widely adopted by textbook publishers.

State Impact

- In interviews with education leaders from 27 states, SRI found that "a remarkably high percentage of them (90%) currently use or refer to *Benchmarks* in their day-to-day work" and 80% of them spontaneously mentioned *Benchmarks* and *Science for All Americans* as a primary source of information. Nearly all the leaders interviewed said Project 2061 had played a major role in defining science literacy in their respective states.
- SRI's review of 43 state curriculum frameworks or standards-type documents and its case studies in Colorado, Georgia, New Jersey, New York, South Carolina, and Wyoming confirm Project 2061's influence on state-level reform efforts.



Individual Impact

- 92% of workshop participants surveyed reported that increasing their familiarity with Project 2061 was of significant or major benefit to their work.
- Teacher educators, in particular, found the workshops very beneficial to their work, and most of them make use of *Science for All Americans* (92%) and *Benchmarks for Science Literacy* (90%) in their practice.
- 85% of the teachers surveyed consider *Benchmarks for Science Literacy* an influence on what they teach, compared to 72% who report their science textbook as an influence.

By 1989—the year *Science for All Americans* was published—educators, political leaders, and families and communities recognized the signs of a failing education system. In science education, Project 2061 offered a vision of what all students could achieve, not just an elite few who would go on to scientific careers. This was a novel idea then. Today it sounds almost commonplace—perhaps the best measure of Project 2061's influence.

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An Innovator in Science Education Reform

In addition to the evaluation by SRI International, Project 2061 was the focus of another large-scale study released in 1996 by the Organisation of Economic Cooperation and Development (OECD). With its focus on innovations in science education around the world, this OECD report features Project 2061 as an example of a prominent U.S. reform effort. Calling it the "single most visible attempt at science education reform in American history," the report concludes with the following summary of Project 2061's major accomplishments:

- ***Project 2061 produced a clear and comprehensive vision of what everyone should know about science.*** **Science for All Americans** ***persuades its readers that virtually everything the non-specialist adult should know about science is interesting and worth learning. It offers a portrayal of the field that is fresh without being radical, accessible without being trivial. Above all, it looks achievable.***
- ***In operationalizing its conception of educational change, the project has addressed at some level almost all the many factors that are believed to affect education reform. In that sense, it exemplifies and pioneers a comprehensive approach to change that has come to be called 'systemic.'***
- ***The project is national and inclusive. It offers a professionally certified version of what every school should strive for in science, wherever its location and whatever the composition of its student body. In doing so, it has generated an example of what nationally driven curriculum reform might look like. As the country began to commit itself to the creation of national standards for the various subjects in the curriculum, Project 2061 was already in a position to offer an illustration, even a prototype, to demonstrate how such standards might play out in practice.***
- ***Project 2061 has enhanced leadership in science education. The professional influence of people who have been associated with the project has been strengthened; whether at one of the six sites or at Washington headquarters, affiliation with Project 2061 has accorded an extra level of legitimacy to the changes in science education that these people have tried to promote.*** **(Atkin et al., 1996)**

A Strong Foundation for Change

In 1985, the American Association for the Advancement of Science (AAAS) launched a long-term effort to reform science, mathematics, and technology education. With Halley's Comet in view that same year, the project's originators found themselves considering all the scientific and technological changes that a child entering school in 1985 would witness before the return of the Comet in 2061. They chose the name "Project 2061" to suggest that meaningful reforms to education depend on a long-term vision of the knowledge and skills that today's students will need as adults in the next century.

Science for All Americans. Project 2061's first task was to clarify what all high-school graduates should know and be able to do in science, mathematics, and technology. Five expert panels—in the biological and health sciences, social and behavioral sciences, physical and information sciences and engineering, mathematics, and technology—debated and finally agreed on the concepts and skills most crucial to science literacy. Their recommendations were integrated in *Science for All Americans* (1989) which became the conceptual basis for Project 2061's subsequent reform efforts.

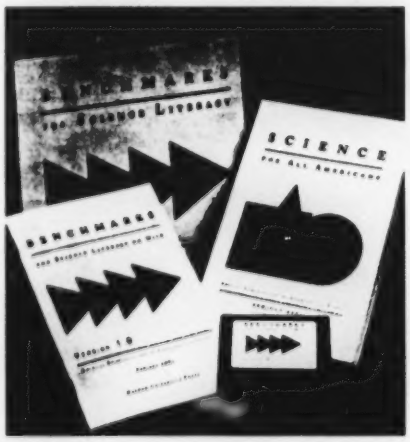
With *Science for All Americans* Project 2061 helped to establish science literacy as an important national goal for all students. It both captured and influenced the growing national consensus on what constitutes science literacy and suggested some guidelines for successful reform. In a joint statement issued in February 1996, AAAS, the National Academy of Sciences, and the National Science Teachers Association affirmed their commitment to the guiding principles that have directed Project 2061's work for more than a decade:

- The first priority of science education is basic science literacy for all students, including those in groups that have traditionally been served poorly by science education, so that as adults they can participate fully in a world that is increasingly being shaped by science and technology.
- Education for universal science literacy will, in addition to enriching everyone's life, create a larger and more diverse pool of students who are able to pursue further education in scientific fields and are motivated to do so.
- Science literacy consists of knowledge of certain important scientific facts, concepts, and theories; the exercise of scientific habits of mind; and an understanding of the nature of science, its connections to mathematics and technology, its impact on individuals, and its role in society.
- For students to have the time needed to acquire essential knowledge and skills of science literacy, the sheer amount of material that today's science curriculum tries to cover must be significantly reduced.
- Effective education for science literacy requires that every student be frequently and actively involved in exploring nature in ways that resemble how scientists themselves go about their work.

But how should the nation's 15,000 school districts with their 100,000 schools begin to put these principles into practice? Rather than develop a "one size fits all" curriculum, Project 2061 is developing a coordinated set of reform tools educators can use to design their own curricula, keyed to national learning goals but suited to local circumstances.

School-district teams. To be sure that its work was grounded in the front-line experience of teaching, Project 2061 formed partnerships with six diverse school-district teams of K-12 teachers and administrators. Located in San Antonio, San Francisco, San Diego, Philadelphia, rural Georgia, and suburban McFarland, Wisconsin, the teams collectively represented the nation's diverse school districts.

With support from Project 2061, local universities, and their own school districts, the teams began to map out what students would need to know and



Project 2061's print and electronic tools are available from Oxford University Press.

be able to do as they progressed toward the science literacy goals described in *Science for All Americans*. As the difficult work progressed, all of the teams soon realized that they needed to pin down a common set of specific learning goals at several grade levels within the K-12 span. Their work became the basis for *Benchmarks for Science Literacy*, published in 1993.

Today, the teams set their own agendas for local reform while helping Project 2061 learn more about the sort of help school districts will need in redesigning the curriculum around science literacy goals. Several of the teams have reorganized significantly. For example, the McFarland, Wisconsin, team has given way to a new, statewide Project 2061 network. Team members provide essential feedback and input to Project 2061 on research and development. They also give workshops and presentations on the project's reform tools and provide support and expert consultation services to reformers in states and districts throughout the country.

***Benchmarks for Science Literacy* and *Benchmarks on Disk*.** Intended primarily as a tool for curriculum design, *Benchmarks* provides a coherent set of specific learning goals (or benchmarks) for grades K-2, 3-5, 6-8, and 9-12. The sequence of benchmarks for any given topic reflects a logical progression of ideas, with early-grade benchmarks anticipating the more advanced benchmarks for later grades. Study of research on teaching and learning shaped the content and sequence of benchmarks. Supplemented with integrative essays and cross references to related topics in other sections, *Benchmarks* emphasizes

What Is Science Literacy?

Project 2061 defines science literacy broadly, emphasizing the connections among ideas in the natural and social sciences, mathematics, and technology. Both *Science for All Americans* and *Benchmarks for Science Literacy* include specific recommendations in the following areas:

The Nature of Science **focuses on three principal subjects: the scientific world view, scientific methods of inquiry, and the nature of the scientific enterprise.**

The Nature of Mathematics **describes the creative processes involved in both theoretical and applied mathematics.**

The Nature of Technology **considers how technology extends our abilities to change the world and the considerations necessary for its prudent use.**

The Physical Setting **describes basic knowledge about the content and structure of the universe (on astronomical, terrestrial, and sub-microscopic levels) and the physical principles on which it seems to run.**

The Living Environment **delineates basic ideas about how living things function and how they interact with one another and their environment.**

The Human Organism **characterizes living systems through a focus on the human species as one that is in some ways like other living things and in some ways unique.**

Human Society **considers scientific principles of individual and group behavior, social organization, and the process of social change.**

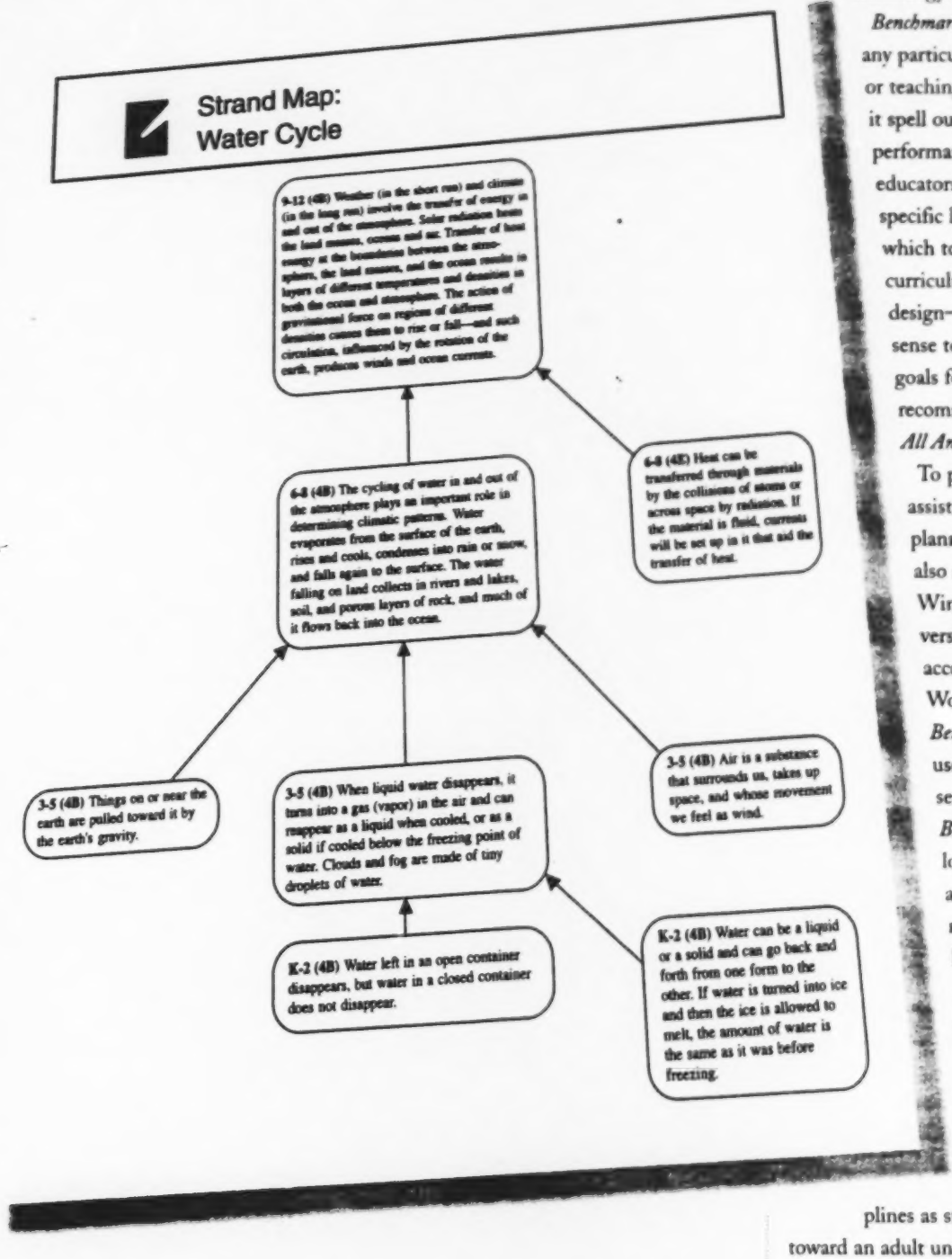
The Designed World **reviews principles of how the world can be shaped and controlled in some key areas of technology.**

The Mathematical World **gives an account of basic mathematical ideas that together play a key role in almost all human endeavors.**

Historical Perspectives **illustrates the science enterprise with 10 historical examples of exceptional significance in the development of science.**

Common Themes **presents general concepts that cut across science, mathematics, and technology.**

Habits of Mind **sketches the attitudes, skills, and ways of thinking that are essential to science literacy.**


Strand Map:
Water Cycle
9-12 (4B) Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the ocean results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall—and such circulation, influenced by the rotation of the earth, produces winds and ocean currents.
6-8 (4B) The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the ocean.
6-8 (4E) Heat can be transferred through materials by the collisions of atoms or across space by radiation. If the material is fluid, currents will be set up in it that aid the transfer of heat.
3-5 (4B) Things on or near the earth are pulled toward it by the earth's gravity.
3-5 (4B) When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.
3-5 (4B) Air is a substance that surrounds us, takes up space, and whose movement we feel as wind.
K-2 (4B) Water left in an open container disappears, but water in a closed container does not disappear.
K-2 (4B) Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

Growth-of-understanding or conceptual "strand" maps portray the sequence and structure of knowledge and skills leading to students' achievement of particular science literacy goals.

the interconnectedness of ideas within and among science, mathematics, and technology.

Benchmarks does not advocate any particular curriculum design or teaching methods, nor does it spell out goals for advanced performance. It simply provides educators with sequences of specific learning goals around which to organize a core curriculum of their own design—one that makes sense to them and meets the goals for science literacy recommended in *Science for All Americans*.

To provide additional assistance to curriculum planners, *Benchmarks* is also available on disk in Windows and Macintosh versions and will soon be accessible on-line via the World Wide Web. With *Benchmarks on Disk*, users can browse or search the entire text of *Benchmarks*, quickly locate cross-references, and consult relevant research on student learning. The disk also presents "benchmark strands" that illustrate graphically how learning goals build upon one another and interconnect across disciplines as students progress toward an adult understanding of a particular science concept.

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Tools for Change

Nearly 130,000 copies of *Science for All Americans* and nearly 80,000 copies of *Benchmarks* have been sold in the U.S. and throughout the world. Both volumes are being translated into Chinese, Spanish, and Japanese. Countries around the world have sponsored conferences on the work of Project 2061, including France, Spain, Taiwan, and the colony of Hong Kong.

But *Science for All Americans* and *Benchmarks* are only the first in a coordinated set of tools that Project 2061 is developing to help educators in their reform efforts. A newly-released CD-ROM and other tools now under development address some of the immediate needs of reformers while also helping them to achieve more far-reaching goals.

Resources for Science Literacy: Professional Development. Educators need new knowledge and skills and a wide variety of materials to plan and implement a K-12 curriculum that promotes science literacy. The *Resources for Science Literacy: Professional Development* CD-ROM can help them to focus curriculum, instruction, and their own professional development on science literacy goals such as those in *Benchmarks for Science Literacy* or the *National Science Education Standards*. This CD-ROM tool offers an array of resources that are relevant to the science literacy goals presented in *Science for All Americans*, including the document's full text which is available for the first time in an electronic format. The resources are keyed to specific topics covered in *Science for All Americans* so that users can search the various databases for pertinent information. A companion print volume introduces the user to the materials included on the CD-ROM, providing helpful background information along with descriptions and samples of the resources themselves.

Professional development specialists, teacher educators, and teachers can use the components of the *Resources for Science Literacy* CD-ROM described below as the basis for a long-term program of study designed to help them to:

- **Expand their knowledge of important ideas in science, mathematics, and technology**

  The **Science Trade Books** database cites over 120 books for general readers on many areas of science, technology, and mathematics. Each entry includes full bibliographic information, reviews, and other descriptive data. Users can search the database by topics found in *Science for All Americans* to compile customized reading lists. Descriptions of 15 **College Courses** offered at ten colleges and universities provide examples and suggest guidelines for designing courses around concepts from *Science for All Americans*.

- **Use *Benchmarks* and standards more effectively**

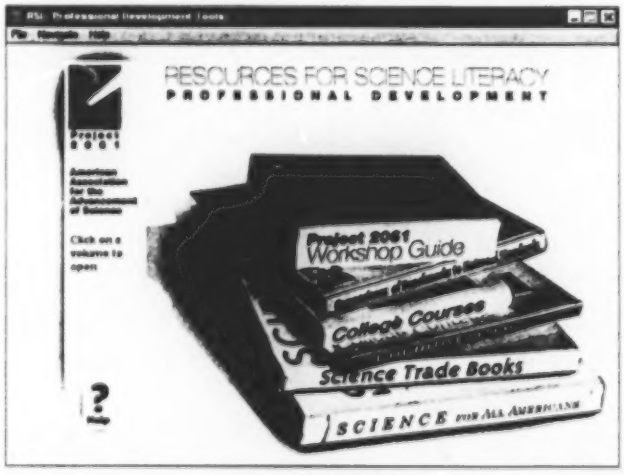
  Detailed **Comparisons of Benchmarks to National Standards** show how Project 2061's benchmarks relate to national content standards in science, mathematics, and social studies. Educators can use this component to compare their own state or district level guidelines to the national content recommendations.

- **Explore how students learn science literacy concepts**

  The **Cognitive Research** database introduces users to research literature that will help them deal with some of the difficulties students may have in learning many of the topics in *Science for All Americans* and *Benchmarks*. In addition to *Benchmarks'* Chapter 15: The Research Base and its bibliography of over 300 references, there are descriptions of more than 100 articles, reports, and videos related to how students learn science literacy concepts at various ages.

- **Provide workshops that promote reform**

  Developed and field-tested by Project 2061 staff, teachers, and education consultants, the **Project 2061 Workshop Guide** includes a rich collection of materials that can be used to design and conduct a variety of workshops to help participants understand science literacy goals and to use them to improve curriculum, instruction, and assessment.



Project 2061's new CD-ROM can be used to create professional development programs that promote science literacy.

Available from Oxford University Press, the *Resources for Science Literacy* CD-ROM will be updated as users recommend additional trade books, research studies, college courses, and workshop activities and materials for inclusion in future editions.

Evaluating Curriculum. Educators need a reliable method for identifying materials that effectively target the learning goals in *Benchmarks* and the *National Science Education Standards*. To that end, Project 2061 is developing a new tool that will include a step-by-step procedure for analyzing curriculum materials for their match to specific learning goals and provide detailed case studies of analyzed materials. This new tool will be released in both print and electronic versions and will be frequently updated as reviews and analyses of additional materials become available.

Project 2061's approach to curriculum evaluation reflects the work of more than a hundred K-12 teachers, teacher educators, materials developers, and cognitive scientists nationwide. During a year-long series of pilot and field tests, these educators used Project 2061's draft analysis procedure to analyze K-12 units (and one year-long curriculum) for their match to *Benchmarks* (and to portions of *National Science Education Standards* that diverge slightly from *Benchmarks*).

Because the procedure has been tested with groups of educators actually responsible for choosing curriculum materials, Project 2061's curriculum evaluation tool should be easy to adapt to the needs of states, school districts, or classrooms.

Designs for Science Literacy. Reforming the entire K-12 curriculum around science literacy goals is a tremendous task, one that requires a long-term, systematic approach. *Designs for Science Literacy* will guide educators by first laying out some general principles of design and suggesting how they can be applied to the curriculum. Next, *Designs* depicts what long-term, computer-aided design of an entire K-12 curriculum might entail. And finally, it advises educators on making short-term changes (for example, removing extraneous topics and details from the curriculum, increasing coherence in the curriculum both across grades and across topics, adjusting assessment to serve learning goals, and experimenting with a variety of instruction) while preparing for a more radical transformation in the long run.

Designs will be produced in print followed by a fully interactive electronic version. Later, user feedback on these first two versions will inform the development of an integrated print/disk version of *Designs*. This will include a substantial database of curriculum components that educators can assemble into a variety of curricula that serve *Benchmarks* or similar sets of science literacy goals.

Atlas of Science Literacy. To participate more effectively in reform, educators need a greater awareness of how students' understanding of key concepts in science, mathematics, and technology might develop and how instruction can interconnect and build on those concepts. To help educators gain such insights, Project 2061 is developing the *Atlas of Science Literacy*, a collection of growth-of-understanding maps that graphically portray the sequence and interdependence of knowledge and skills that lead to students' achievement of particular science literacy goals. Originally undertaken by the project's school-district teams to help them design local curriculum models, the maps led to the development of the grade-specific benchmarks themselves. The *Atlas* will help educators see how ideas in the curriculum connect across grades or across disciplines and topics.

Blueprints for Reform. To succeed, reform of the curriculum requires adjustments in other areas of the education system. Committees of specialists in a dozen areas of the education system have drafted concept papers for Project 2061 to identify changes needed in teacher education, school organization, assessment, materials and technology, equity, policy, finance, curriculum connections, research, higher education, family and community, and business and industry.

Project 2061's Curriculum Analysis Procedure

Project 2061's procedure requires four critical steps:

REVIEW THE MATERIAL. A preliminary inspection of the material determines whether it merits further analysis. If so, specific learning goals or benchmarks are identified to be the focus of the analysis.

ANALYZE CONTENT. Examine the material's content in detail for its alignment to the specified learning goals. If this step reveals a match, the analysis continues.

EVALUATE INSTRUCTIONAL STRATEGY. Using criteria derived from research on student learning and on effective teaching, estimate how well a material's instructional strategies support student learning of the ideas and skills for which there is a content match.

SUMMARIZE FINDINGS. Collect and document evidence showing how the material's content and its instructional strategies relate to the learning goals and draw conclusions on the material's strengths and weaknesses.

In addition, over the past year, a series of focus groups has brought together the authors and other experts to update, review, and enhance the papers.

The *Blueprints* papers will soon be accessible through Project 2061's World Wide Web site. Electronic forums and other interactive exchanges will be developed to encourage more extensive public debate of the important issues that are explored in the papers. *Blueprints* should be helpful to school-district-level educators with broad responsibilities as well as to science, mathematics, and technology specialists.

Eventually, Project 2061 intends to develop an online, multimedia system that will integrate all of the project's other tools to assist educators as they reform their local curricula. It will give users easy access to Project 2061 tools in the order or form best suited to their specific needs. The system will also include numerous databases with resources and examples that relate to Project 2061's reform tools. For example, educators will use the online system to:

- analyze or design curricula around specific learning goals;
- evaluate and select curriculum resources and assessment materials;
- locate information on relevant programs and resources;
- plan professional development programs;
- record student progress within a curriculum; and
- keep up with latest education research and new developments in curriculum design.

With the system accessible on the Internet, Project 2061 can immediately update materials, gather feedback, and promote dialogue among educators using Project 2061 tools.

Project 2061
Having an Impact

Preparing Teachers in Maryland and Colorado

Specific learning goals for all students in science, mathematics, and technology education put new demands on teachers. Last year, Project 2061 received funding from the John D. and Catherine T. MacArthur Foundation to rethink teacher preparation around the challenging learning goals in *Benchmarks for Science Literacy* and the *National Science Education Standards*. Under the grant, Project 2061 is working closely with university/school-district collaboratives in Maryland and in Colorado to help them develop model programs for preparing K-12 teachers and supporting them during their first years in the classroom. Both Maryland and Colorado recently received grants from the National Science Foundation and the U.S. Department of Education to reform teacher preparation statewide and already have in place several major initiatives focused on science literacy.

The Maryland team involves education faculty from Towson State University, teachers and administrators from the Baltimore County School District, and several state policy makers. In Colorado, teams are made up of representatives from six universities along with master science teachers from partner schools throughout the state. Over the next three years, the teams at both sites will be working to:

- **revise existing and develop new college science courses around ideas from *Science for All Americans*;**
- **incorporate into teaching-methods courses the study of *Benchmarks for Science Literacy* and its practical uses (for analyzing curriculum materials and assessment and designing instruction);**
- **support the professional development of a cadre of experienced K-12 teachers to serve as mentors to new teachers; and**
- **help align state credentialling and professional development policies and practices with reform for science literacy.**

The models for teacher preparation resulting from this effort will be shared with more teacher educators through training conferences and a final report. Also, the next edition of Project 2061's *Resources for Science Literacy: Professional Development* will include workshops and university courses produced by the two sites.

Putting Learning Goals to Work

Making changes in curriculum and instruction ultimately depends on classroom teachers and the tools they have to work with. Through its many workshops, Project 2061 has learned a good deal about what it will take to prepare K-12 teachers to promote science literacy. According to SRI International's study of Project 2061, many teachers and teacher educators are already using *Benchmarks* and *Science for All Americans* in their work.

To find out more about the kinds of tools and support that educators will need to help their students achieve science literacy, Project 2061 gathers firsthand information through workshops conducted by staff and by members of the school-district centers. Over the past year alone, more than 4,000 educators have attended 150 Project 2061 workshops requested by teacher groups, curriculum committees, and professional organizations at the district and state levels. According to SRI's survey of 309 participants, a vast majority found that the workshops benefited their work.

Curriculum reform. Project 2061 has spent several years considering how specific learning goals, like those in *Benchmarks* or *National Science Education Standards*, would affect curriculum and instruction. Through workshops and new reform tools such as *Resources for Science Literacy*, Project 2061 is sharing what it has learned.

For example, workshop experiences show that it is important to sensitize educators to the value of understanding the precise intent of *Benchmarks* or any set of specific learning goals. For example, *Benchmarks*' recommendation that students acquire a general understanding of the functions of the cell does not justify requiring students to memorize dozens of specialized terms about the cell. With careful study, educators begin to realize that *Benchmarks* and the various national standards are neither vague guidelines nor a new arrangement of familiar topics, but very specific statements of what is most important to learn about a topic.

Misinterpretations can lead right back to the same old curriculum. That is why Project 2061 workshops on analyzing or improving curriculum, instruction, and assessment always engage participants in the study of particular learning goals. For much the same reason, Project 2061 has spent the past year developing and refining a step-by-step procedure (presented as a workshop on the *Professional Development* CD-ROM and in much greater depth on the curriculum evaluation tool now underway) to help educators judge how well curriculum materials serve specific science literacy goals.

Teacher preparation. Many teacher educators attend Project 2061 workshops at professional meetings. Some already use *Science for All Americans* and *Benchmarks for Science Literacy* in their education courses. Project 2061 staff and school-district team members have also worked closely with faculty at dozens of universities to develop courses around *Benchmarks for Science Literacy* for prospective and practicing teachers.

With a grant from the MacArthur Foundation, Project 2061 is working closely with teachers and teacher educators in Colorado and Maryland. Each state is developing a model for improving the preparation of teachers so that they are better able to teach to specific content standards in science, mathematics, and technology.

In addition, Project 2061 has involved teacher educators (including college faculty responsible for teaching science and mathematics to prospective teachers) in the development of three of its reform tools:

- For *Blueprints for Reform*, Project 2061 commissioned education faculty at the Michigan State University to study how teacher education should change to accommodate the curriculum reforms proposed by Project 2061. The project then held a series of conferences for faculty from dozens of universities to discuss the resulting draft reports and add suggestions of their own.
- For *Resources for Science Literacy: Professional Development*, arts and science faculty at a dozen higher-education institutions analyzed their course syllabi for links to ideas in *Science for All Americans*. In the process, they helped the project to refine an analytical framework for reviewing existing college courses or creating new ones around science literacy goals.
- Teacher educators collaborated with teachers and materials developers and researchers to refine and field test Project 2061's curriculum-analysis procedure, which will eventually be accessible online through Project 2061's World Wide Web site.

By including teacher educators in its research and development, Project 2061 hopes not only to develop tools useful in teacher education programs, but to stimulate discussion at colleges and universities about how reforms in higher education can support reforms in grades K-12.

PROJECT2061
Having an Impact

Roosevelt School for Design and Technology

When staff at this high school in San Antonio's North East Independent School District decided to restructure their school and focus on design and technology, they called on Project 2061's local school-district team for help. The team was already helping other schools throughout the District rethink their curricula around science literacy goals.

The team's collaboration with the Roosevelt staff began with a series of introductory workshops on Project 2061's reform tools *Science for All Americans* and *Benchmarks for Science Literacy*. The school's entire science and mathematics faculty then received additional training in analyzing curriculum materials and planning instruction around science literacy goals. "We want to focus on providing challenging standards-based requirements for all students," reports Roosevelt's principal Robert Todd. "Project 2061 is an excellent vehicle to help us accomplish our goals." As part of San Antonio's Urban Systemic Initiative, Roosevelt will also participate in the redesign of their science and mathematics program based on Project 2061's *Benchmarks* and the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics*.

Roosevelt High School freshmen Camel Morgan, 15 (left), and Darrell Caldwell, 14, watch as retired Air Force Col. Pat Reese launches a rubber band-propelled glider as part of a course Reese designed for students who failed their eighth-grade Texas Assessment of Academic Skills test. The class, incorporating math, science, reading and language arts, was funded by a $30,000 grant from the San Antonio Alliance for Education. Students launched model F-16 jets to gather data, predict variables and test hypotheses.

School staff are also interested in using the Project 2061 team's Designed World Curriculum Model, which organizes the entire curriculum around the six major areas of technology identified in *Science for All Americans*' (and *Benchmarks*') Chapter 8: The Designed World. Faculty from the Engineering Department of the University of Texas at San Antonio and Dr. Arnold Wasserman, Senior Research Fellow of the Corporate Design Foundation, have joined the Project 2061 team in helping Roosevelt's staff to implement the model.

Roosevelt is a large school with about 4,000 students, and dramatic changes will not take place overnight, says Project 2061 team leader Joan Drennan-Taylor. But this year the freshman class began a science and mathematics program based on *Benchmarks* and the mathematics standards. Reforms will keep pace with the students over the next four years, so that by the time they graduate in 2000, they will have had full benefit of Roosevelt's transformed curriculum.

Students at Roosevelt High School in San Antonio launch model F-16 jets to gather data, predict variables, and test hypotheses. They participate in a special class that incorporates math, science, reading and language arts funded by a grant from the San Antonio Alliance for Education and Project 2061.

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PROJECT2061
Having an Impact

A *Benchmarks*-based Curriculum at the San Francisco Community School

This is one of nine schools working closely with Project 2061's local school-district team to develop and implement "challenge-based learning experiences" in which students are aware of a purpose, meaningful and motivating to them, around which activities are organized and which targets learning goals from *Benchmarks*. Last year, first- and second-graders built a model of the space shuttle. In grades 3-5, some students designed their own National Park, while others created an oceanarium. Middle-school students created animated movies about events of the 20th century and studied issues raised by genetic engineering. In each case, says teacher Debbie Faigenbaum, the challenges "covered significant portions of science, mathematics, and language arts curricula."

This innovative, *Benchmarks*-based curriculum requires an equally innovative approach to assessment. With support from the Robert N. Noyce Foundation, the school brings together parents, community members, and teachers to evaluate how well the learning experiences convey important ideas to students. Using questionnaires to probe student understanding of the targeted benchmarks provides an "amazing professional development experience for the teachers and shows parents how the benchmarks link to classroom instruction and to assessing what students actually learn," says Faigenbaum. And, she adds, the kids love all of the attention.

Boston's Museum of Science Promotes Science Literacy

Exhibits director Larry Bell and his staff drew on *Science for All Americans* to design *Investigate! A See-for-Yourself Exhibit*, the second phase of a new interactive installation which opened last year at the Museum of Science in Boston.

"*Science for All Americans* helped us realize that an important part of understanding science includes learning how to think scientifically," says Bell. Rather than organizing the exhibit around scientific disciplines or traditional textbook topics, *Investigate!* focuses on scientific thinking skills such as observing, experimenting, and analyzing data. Visitors step into the role of scientist: asking questions, making measurements, and interpreting the results of their experiments. As they move through the exhibit, they can use a skin sensor to measure their bodies' reactions to stimuli; determine whether blowing on a hot liquid really cools it down; recreate Galileo's Tower of Pisa experiment; or design, build, and race a scale-model solar car. They are encouraged to draw conclusions from data they accumulate and to record those conclusions at computer stations throughout the exhibit for other visitors to see.

The museum also uses *Benchmarks* extensively in its educational and volunteer programs. Education staff use *Benchmarks* to outline what children can be expected to understand at different ages and to help them understand topics in the Massachusetts curriculum framework, which is based on *Science for All Americans*, *Benchmarks*, and the *National Science Education Standards*.

Shaping the National Agenda

SRI International's study shows that Project 2061 has had a "broad and substantive impact" that has "changed the terms of the national discussion on science education reform." While helping to establish science literacy as a national goal for all students, Project 2061 has also provided a model for a variety of other reform efforts.

National Science Education Standards. Project 2061's impact at the national level is perhaps most evident in the *National Science Education Standards (NSES)* published in early 1996. Developed by the National Research Council at the request of the U.S. Department of Education, the National Science Foundation, and other federal agencies, *NSES* provides recommendations for science content, teaching, professional development and assessment practices, school science programs, and the overall K-12 educational system.

To develop its science content standards, the National Research Council drew heavily on *Science for All Americans* and *Benchmarks for Science Literacy*, acknowledging in the introduction to *NSES*:

> The many individuals who developed the content standards sections of the *National Science Education Standards* made independent use and interpretation of the statements of what all students should know and be able to do that are published in *Science for All Americans* and *Benchmarks for Science Literacy*. The National Research Council of the National Academy of Sciences gratefully acknowledges its indebtedness to the seminal work by the American Association for the Advancement of Science's Project 2061 and believes that use of *Benchmarks for*

Science Literacy by state framework committees, school and school-district curriculum committees, and developers of instructional and assessment materials complies fully with the spirit of the content standards. (National Research Council, 1996)

To reassure educators of the strong consensus among experts on what students should know and be able to do in science, Project 2061 has prepared a detailed comparison of the content portion of *NSES* with *Benchmarks*. This comparison indicates that despite differences in organization, the two documents are very much alike, sharing about 90% of the same content recommendations. Both documents emphasize understanding ideas over memorizing technical terms, and exclude a host of topics—Ohm's law, series and parallel circuits, phyla of plants and animals, balancing chemical reactions, to name a few—that now overload the traditional science curriculum. They also describe most ideas and topics at the same levels of difficulty and detail, placing them within comparable grade ranges.

Other standards. Because Project 2061 defines science literacy broadly, there is considerable overlap between *Benchmarks for Science Literacy* and two other sets of national standards, the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989) and *Curriculum Standards for Social Studies* (National Council for Social Studies, 1994). These documents share with *Benchmarks* and *NSES* some general assumptions about reform, namely that reform should center on explicit and developmentally-appropriate learning goals defining a common core of learning for all students, and that this core curriculum should cover less material, so that students can learn the most important ideas well. Comparisons of *Benchmarks* to the national standards in mathematics, science, and social studies are included on the Project 2061 CD-ROM *Resources for Science Literacy: Professional Development*.

Reform initiatives. Project 2061's vision and philosophy of reform have helped to guide a number of federal and national reform initiatives. The National Science Foundation urged applicants to its Statewide Systemic Initiatives (SSI) program to study the learning goals in *Science for All Americans*. *Science for All Americans* was also used as a model by states funded by the U.S. Department of Education to develop curriculum frameworks for mathematics and science education.

Many organizations with national influence, such as the New Standards Project and the Council for Basic Education, follow Project 2061's work closely and actively promote it. Project 2061 is regularly represented at meetings of the National Science Teachers Association, the Association for Supervision and Curriculum Development, the National Association of Elementary School Principals, Association for the Education of Teachers of Science, National Science Education Leadership Association, American Association for Higher Education, American Association of Colleges of Teacher Education, and many other organizations.

Curriculum developers. With textbooks still driving the curriculum in many classrooms, publishers exert a strong influence on reform. However, SRI International's survey of textbooks indicates that even those that cite the importance of *Science for All Americans*, *Benchmarks for Science Literacy*, or *National Science Education Standards* do little to actually promote learning goals from those documents.

Over the next few years, Project 2061 will intensify its efforts to promote the alignment of curriculum materials and assessment with science literacy goals.

Through workshops with not-for-profit curriculum developers such as BSCS, EDC, the Lawrence Hall of Science, the Association for the Integration of Mathematics and Science, the National Science Resources Center, the American Chemical Society, and others, Project 2061 has already stimulated interest in tying instructional materials more closely to *Benchmarks*. Some commercial publishers—for example, Scholastic and Silver Burdett Ginn—have also begun to incorporate Project 2061's *Benchmarks* into their print and electronic products.

With the release of the *Resources for Science Literacy: Professional Development* CD-ROM and the refinement of a procedure for analyzing curriculum materials for their match to learning goals, Project 2061 will be better able to help teachers themselves to choose among—and improve upon—a wide array of curriculum materials.

Informal science programs. Project 2061's work has served as a catalyst for several exhibits in museums and science centers around the country. These include *Investigate!*, the Boston Museum of Science's new hands-on exhibit; *Science Alive!*, an interactive science center in Grand Rapids, Michigan; and a series of new exhibits at the Cranbrook Institute of Science in Bloomfield Hills, Michigan. Project 2061's work has also guided the producers of television programs such as *Scientific American Frontiers* and *The New Explorers*.

When Joseph A. Miller, Senior Vice President and Chief Technology Officer for DuPont, co-chaired Delaware's science standards committee, he wanted to become knowledgeable about the content before he began his work. He prepared by reading Science for All Americans. *Miller advises business leaders with similar responsibilities in their own communities to do the same.*

THE BUSINESS ROUNDTABLE, JUNE 1996

Guiding Reform in the States

State and local leaders in education often learn about Project 2061 through its publications or workshops. In some states—California, Georgia, Texas, Pennsylvania, and Wisconsin—Project 2061's school-district teams work closely with educators in their own and neighboring school districts, frequently serving as advisors to other important reform initiatives and to curriculum committees. These long-term collaborations have helped both Project 2061 and the states to achieve common goals. For example:

- In California Project 2061 has worked closely since 1989 with teams of teachers and administrators in San Francisco and San Diego. In 1990, California became one of the first states to develop a science curriculum framework and it used *Science for All Americans* as its model. Today, in addition to providing workshops for the state's educators, Project 2061 is field-testing its curriculum-analysis procedure in California.
- In Georgia, Project 2061 has had an important impact on textbook adoption—all three of the districts visited for the SRI study had been "significantly influenced by Project 2061 in their adoption process."
- Project 2061 maintains a close working relationship with many of the National Science Foundation's Statewide and Urban Systemic Initiatives. Project 2061 staff and members of the project's School-Districts Centers serve as consultants to Systemic Initiative programs in New Jersey, California, Texas, Pennsylvania, and Georgia. All of the systemic initiative sites are using both *Science for All Americans* and *Benchmarks* in their reform efforts.

Education leaders often hear of Project 2061 through other reform initiatives influential in their states, as in the following examples:

- The Council of State Science Supervisors takes an active interest in Project 2061's work, and has arranged for Project 2061 updates and workshops at all of its annual meetings since 1993.
- Organizations such as the Council for Basic Education, the International Baccalaureate Organization, the National Association for Research in Science Teaching, and many others sponsor Project 2061 workshops, institutes, and presentations.
- Last spring, both *Science for All Americans* and *Benchmarks* were cited as resources during the National Education Summit convened by the nation's governors and CEO's of many major corporations.

State Leaders Report on the Use of Science Education Documents (n = 39)

Document	Percentage Using
Benchmarks for Science Literacy	90%
National Science Education Standards	85%
Science for All Americans	64%
The Core Content: Scope Sequence, and Coordination	44%
Frameworks and other documents from other states	41%
A previous science framework in the state	39%
A High School Framework for National Science Education Standards	21%
Benchmarks on Disk	21%

SRI INTERNATIONAL, 1996

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State curriculum frameworks. Although many states have now adopted their own standards or frameworks to guide their reform efforts, Project 2061 ideas often appear in the documents that define a state's education goals. Even before the publication of *Science for All Americans* in 1989, California drew heavily on drafts of Project 2061's report to prepare its 1990 science curriculum framework, which in turn influenced frameworks in many other states. *Benchmarks for Science Literacy* (1993), with its specific learning goals at four grade levels, has provided even more guidance to committees developing frameworks in the past few years.

SRI International's survey of 43 state curriculum documents reveals that many of them cite Project 2061 and its publications as key sources in their bibliographies, quote directly from Project 2061 publications to describe their vision of science literacy or rationale for reform, or organize their own recommendations according to topics in *Science for All Americans* and *Benchmarks*. Some even adopt Project 2061 benchmarks verbatim. In cases where frameworks refer only loosely to Project 2061, their authors,

Project 2061 Having an Impact

Indiana Science Proficiency Guide

Six years ago, Indiana issued a State Science Proficiency Guide based largely on *Science for All Americans*. This year, the committee updating the guide intends to take full advantage of *Benchmarks for Science Literacy*.

State science supervisor Kevin Beardmore first suggested that the curriculum committee adopt learning goals directly from *Benchmarks*. In this way, he argued, they could avoid the laborious—and redundant—process of developing a good set of learning goals from scratch. After reviewing *Benchmarks*, the committee decided to adopt verbatim virtually all of *Benchmarks*' recommendations for science content and many recommendations from *Benchmarks*' Chapter 9: The Mathematical World. They would have liked to incorporate additional mathematics and social science benchmarks—in fact, the committee even discussed simply buying 20,000 copies of *Benchmarks* to distribute to schools throughout the state—but were checked by state law circumscribing the scope of the Science Guide.

Indiana's curriculum committee is now drafting vignettes of how sets of benchmarks might be taught in the classroom. Beardmore stresses that these vignettes do not prescribe instruction in detail, but hint at possibilities on which teachers can build. He expects Project 2061's new *Resources for Science Literacy* tool will also help educators in implementing the Guide's content recommendations when they are released in the 1997-98 school year.

Working with the Philadelphia Urban Systemic Initiative

The Philadelphia Project 2061 team has been working closely with the local Urban Systemic Initiative (USI), one of the National Science Foundation's programs to improve science, mathematics, and technology education. The co-directors of the USI, Rita Rice and Clara Tolbert, are both Project 2061 team members. Working with other team members they conducted a three-week USI Summer Institute for 100 local teacher leaders representing eight of the District's "clusters" (high schools and the elementary and middle schools that feed students into them). Participants learned about Project 2061's reform tools and then spent a week analyzing and modifying a curriculum unit around *Benchmarks* to implement in their classrooms. With Philadelphia's new content standards in science, mathematics, and problem-solving largely based on *Benchmarks for Science Literacy*, and also on the *National Science Education Standards*, the demands for such workshops are likely to increase over the next few years.

"The Institute gave teachers a chance to be reflective about learning goals," explains Project 2061 team leader Marlene Hilkowitz. "After the session, the teachers said they could never again teach without considering specific learning goals. They recommended that all science teachers go through the same process. It was great to hear them say, 'Finally, a professional development workshop we can really use!'"

Project 2061
Having an Impact

Rhode Island Science Framework

Rhode Island's State Coordinator of Mathematics, Science, and Technology, Dennis Cheek, found *Benchmarks for Science Literacy* to be "the best national document" on which to base his state's new Science Framework. The Rhode Island Framework includes a selection of learning goals, drawing heavily on *Benchmarks* Chapter 4: The Physical Setting, Chapter 5: The Living Environment, and Chapter 6: The Human Organism. The Framework also includes all of the benchmarks from Chapter 3: The Nature of Technology. "This is probably the area least understood by teachers," Cheek points out, "so this is where they need the most help."

With Project 2061's *Benchmarks* supplying the content recommendations for their Framework, Rhode Island's science curriculum committee could concentrate on building their own content knowledge and then creating good examples of how the content might be taught. For each benchmark, the Framework suggests an activity already in use in a Rhode Island classroom, an appropriate assessment for that activity, related themes (systems, models, constancy and change, scale) from *Benchmarks* Chapter 11, and related process skills, including "habits of mind" from *Benchmarks* Chapter 12. In addition, the Framework includes a number of vignettes depicting benchmark-rich classroom activities that are now underway.

Educators throughout Rhode Island seem receptive to the Framework, according to Cheek, but don't necessarily understand what benchmarks imply for curriculum and instruction. He says that implementing the Framework will therefore involve training local curriculum groups, district by district, to analyze their own curricula for a match to benchmarks.

Georgia Framework for Learning and Science

Over the past few years, members of Project 2061's school-district team in rural Georgia have earned reputations as local leaders of reform. Together, they have offered extensive training to colleagues on using Project 2061 tools, and members of the team serve as consultants to other reform projects throughout the state. Recently, several team members helped the Georgia Statewide Systemic Initiative to develop a framework for mathematics and science. As a result, the science portion of the framework is based on *Benchmarks for Science Literacy*.

How much this Georgia Framework for Learning Mathematics and Science will influence the state's existing Quality Core Curriculum remains to be seen, but SRI International's recent evaluation of Project 2061's impact on education indicates that the *Benchmarks*-based Georgia Framework already has support from the Georgia Council of Teachers of Mathematics, the Georgia Science Teachers Association, the State Board of Education, teachers, teacher educators, and the business community. In addition, Sue Matthews, one of the leaders of Project 2061's Georgia school-district team, was recently named to the committee revising Georgia's Quality Core Curriculum in Science for grades K-5; she reports that other members of the committee are eager to use *Benchmarks for Science Literacy* to inform the revisions.

when interviewed, readily acknowledge Project 2061's direct influence on decisions about what content to include.

Despite these encouraging signs, much work remains to ensure that curriculum committees make more effective use of *Benchmarks for Science Literacy*, *Science for All Americans*, or any other set of national standards. In a close examination of a dozen frameworks, SRI found that while they capture "the spirit and essence of the national standards and the *Benchmarks* remarkably well," they often omitted major content areas from *Benchmarks*, simplified content, or restated ideas in terms too general to be useful. Project 2061 will continue to develop new tools and to work directly with state curriculum committees to help them use *Benchmarks* to full advantage.

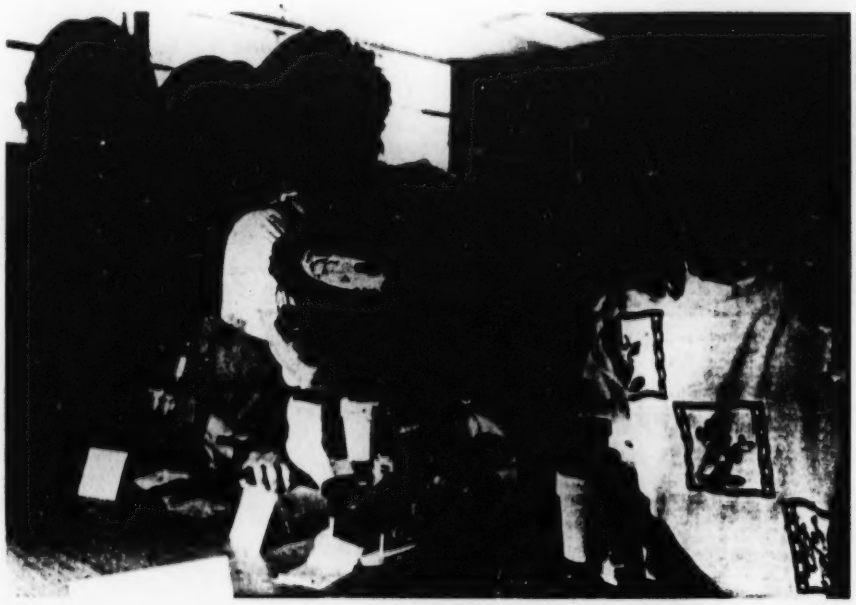
Textbook adoptions. SRI International's study finds that *Science for All Americans* and *Benchmarks for Science Literacy* are useful also to committees deciding on textbooks for their states or districts. *Benchmarks*, in particular, can help these committees set criteria for textbook content at various grade levels. Taking a close look at several school districts in Georgia, SRI noted that committees responsible for choosing science texts took into account which textbooks attempt to incorporate Project 2061 principles, and even rated textbooks for how well they serve particular benchmarks.

A Long-Term Vision

Results from the 1994 National Assessment of Educational Progress and the recent Third International Mathematics and Science Study (TIMSS) show that student achievement in science and mathematics continues to be disappointing. The performance of U.S. students lags behind that of students from many other countries. The TIMSS findings also point to the shortcomings of U.S. curricula, which lack coherence and cover vast numbers of unrelated topics. These and other studies reaffirm Project 2061's emphasis on more focused content and how that content is taught. Clearly, much remains to be done.

For its part, Project 2061 will continue to develop innovative yet practical tools educators can use to put science literacy goals to work at every level of the education system. It will help educators to rethink the core curriculum, reducing the number of topics covered so that students have time to learn the most important concepts well. Project 2061 will work to make its vision of science literacy a reality for all students. What was true in 1989 when *Science for All Americans* was published remains true today:

> "There are no valid reasons—intellectual, social, or economic—why the United States cannot transform its schools to make scientific literacy possible for all students. What is required is national commitment, determination, and a willingness to work together toward common goals."



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